Calculation of Ultraviolet Radiation Quantities using TOMS Ozone and ISCCP Cloud Data

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Acknowledgments

The authors would like to thank Chris Fischer for the TOMS−based calculations for Figure 4. B.M. was supported by a research grant from the German Academic Exchange Service (DAAD). S.M. was supported by the Department of Energy through grant No. DE−A105−94ER61879. NCAR is sponsored by the National Science Foundation. The maps were created with the free GMT package by P. Wessel and W. H. F. Smith.

1 Abstract

UV irradiance and actinic flux are calculated using two different approaches; (A) a well established TOMS cloud reflectivity method [1]; and (B) a new method, based on total ozone from TOMS and cloud parameters from ISCCP. Both products show good agreement between each other, and with ground-based measurements.

2 Methods

A. TOMS−based method. Surface radiation is calculated by scaling the cloudless sky value with a wavelength−independent factor γ which is derived from the TOMS reflectivity according to [1], [3]:

$$E = \gamma \cdot E_{\mathrm{clear}}$$

B. ISCCP−based method. Radiation is cal−culated using cloud fraction and cloud optical depth from the ISCCP D1 data set [5]. Bro−ken clouds are considered with the independent pixel approximation [4], [3]:

$$E = (1 - c) \cdot E_{\mathrm{clear}} + c \cdot E_{\mathrm{cloudy}}$$

where c is the cloud fraction, and E_{clear} and E_{cloudy} are the irradiances for cloudless and totally cloud−covered sky, calculated using the TUV radiative transfer model [2]. The snow cover information of the ISCCP D1 data is used to estimate the correct surface albedo. In both methods, cloudless sky irradiance is calculated using TOMS total ozone.

3 Results

Fig. 1 shows good agreement in the erythemal irradiance calculated using both methods. While the TOMS−based method provides a quick way to calculate surface irradiance and even actinic flux or j−values (Fig. 2) [3], the ISCCP−based method might be of advantage for certain applications because: (1) some extra uncertainty is introduced when using TOMS reflectivity to calculate the actinic flux [3];

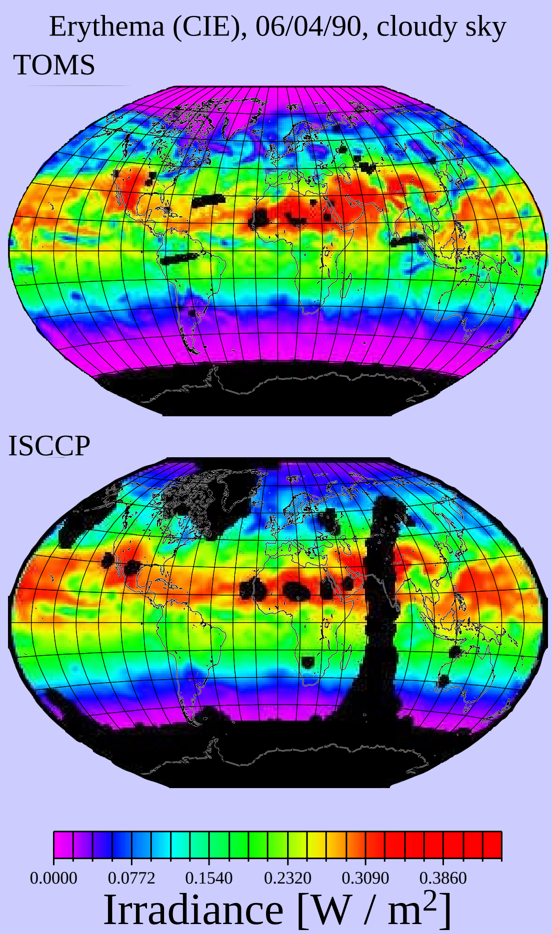

Figure 1: TOMS− and ISCCP−based noontime erythemal irradiance.

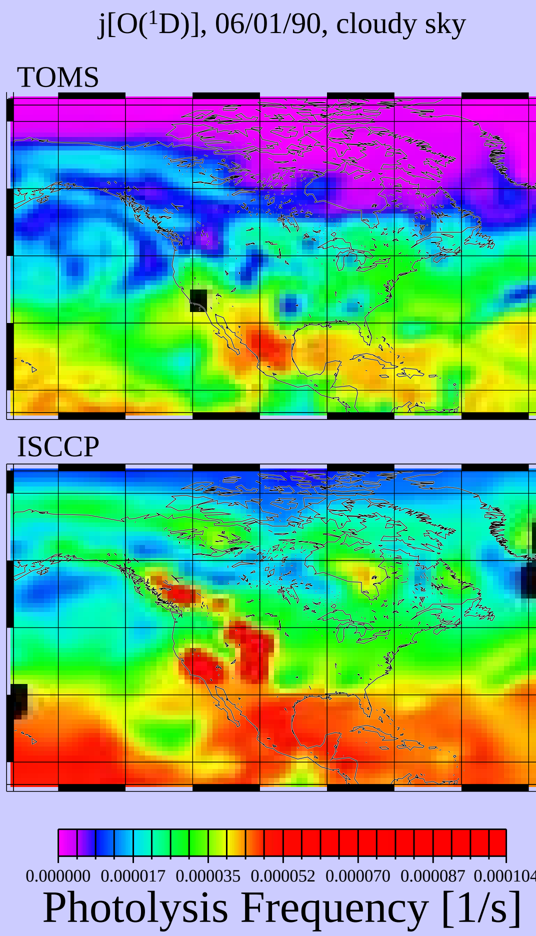

Figure 2: TOMS− and ISCCP−based noontime photolysis frequency $j[O(^1D)]$.

(2) the ISCCP data distinguish between clouds and surface albedo; (3) the ISCCP data include information about the vertical layering of the clouds; and (4) the time resolution of the ISCCP data is higher.

The ISCCP D1 data are available in steps of 3 hours, thus allowing the calculation of diurnal variations. Here, nine data points, equally spaced in time and centered around local noon, are sufficient to calculate daily doses with an accuracy of 1% compared to a calculation with high time resolution. Fig. 3 shows a pronounced diurnal variation of cloudiness, which can only be obtained from the ISCCP data.

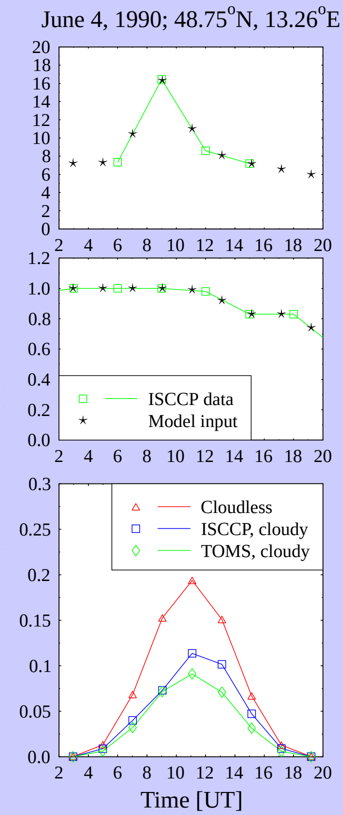

Figure 3: Diurnal variation.

A comparison of the TOMS−based data with ground−based measurements from the World Ozone and UV data center (WOUDC) shows good agreement (Fig. 4). A systematic difference of 5−10% is expected because most of the measured data were not corrected for the cosine error of the entrance optics.

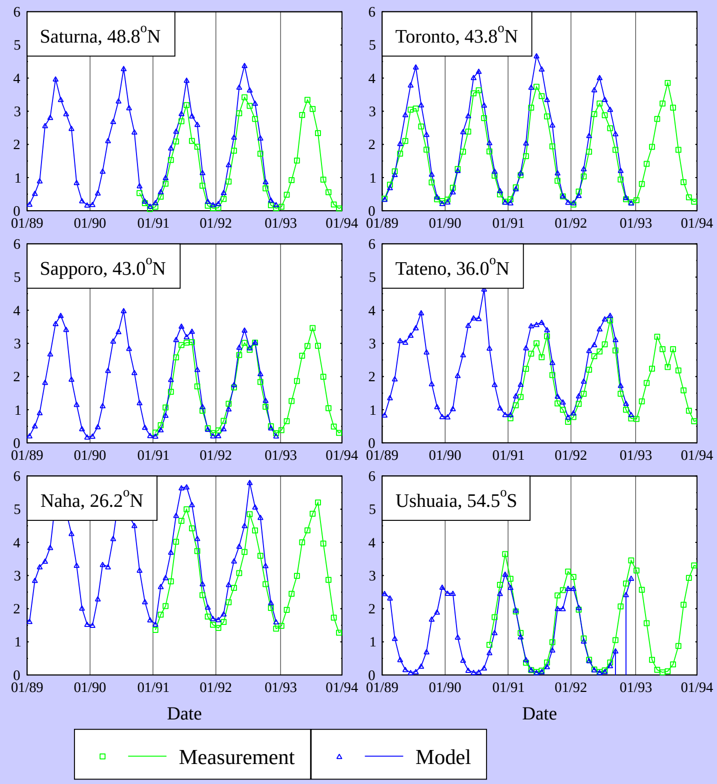

Figure 4: Model calculations and measurements of averaged daily erythemal irradiation.

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